ANALYSIS

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DISCOVERY

Effect of plant materials against *Trogoderma granarium* Everts (Coleoptera: Dermestidae)

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ABSTRACT

Laboratory experiments were conducted to evaluate the efficacy of different plant materials against *Trogoderma granarium* Everts. The treatments used in the study were neem, turmeric, ajwain, mint along with control. All treatments were replicated three times.

All the plant materials were applied at the rate of 2% in 200 grams of wheat. Ten adult *T. granarium* of mixed sex were released in individual replication. The data was collected on adult mortality after 24 hours, 48 hours and seven days of the release. Population fluctuation data was collected on monthly basis for three months, whereas, weight loss was recorded at the end of experiment. Results of the study indicated promising effect of all the materials to cause mortality of *T. granarium* in wheat after one week with (93.30%) mortality recorded in mint, followed by neem (83.30%), turmeric (43.30%), and ajwain (66.70%). The Significant results for the population fluctuation of *T. granarium* in wheat treated with various plant extracts were observed. At the end of third month, the highest population of *T. granarium* was recorded in control (41.67±2.60 beetles), whereas, the lowest (16.33±0.88 beetles) population observed in mint treatment. The population of beetle in remaining treatments was recorded as ajwain, turmeric and neem treatments were 30.00±2.08 beetles, 29.33±1.45 beetles, and 17.33±1.20 beetles, respectively. In view of the mortality and population development among various treatments, the highest overall (27.33%) and grain weight loss (32.83%) was recorded in control, while the lowest overall (8.33%) and grain weight loss (11.00%). was recorded in mint treatment. Based on the present research work it has been concluded that the extract of mint should be mixed with stored wheat grains to minimize the damage of *T. granarium*.

Keyword: Effect, Plant materials, *Trogoderma granarium*, Coleoptera: Dermestidae

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop for many countries, where it is consumed as a staple food (Kazemi *et al.*, 2015). Wheat crop is one of the most important staple food crops in Pakistan in relation to production and utilization and the chief source of protein as compared to maize and rice (Ileke, 2011). In 2017-2018, the wheat crop was planted on an area of 8.734 million hectares, a decrease of 2.6 percent, compared to 8, 9720000 hectares during the 2016-17 periods (same period last year). The shortfall in production is attributed to decline in cultivated area, prolonged and delayed in sugarcane crushing time, severe water scarcity and fog and smog in the wheat-cultivated areas (GOP, 2018).

In agriculture, the use of energy per unit area is related directly to the production level and consumption of inputs; associated energy could be categorized as indirect and direct energy. The direct energy essential for on-farm activities, particularly the energy required from field preparation to harvesting and transportation (Kazemi *et al.*, 2015). Moreover, energy input-output offers a significant understanding of agriculture as a producer and user of energy and it can prompt more effectual and environment-friendly production. Supplement of adequate amount of energy inputs is essential for better production of agricultural products (Risoud, 2000; Moreno *et al.*, 2011; Baran, 2017). Post-harvest losses of stored grains are a severe problem in the developing countries in particular, where poor sanitation and inappropriate storage facilities are available. Due to improper storage conditions, the stored grains suffered from heavy economic losses. Insect pests infest the stored grains and cause heavy economic losses (Fornal *et al.*, 2007). The major insect pests of stored wheat included *Trogoderma granarium* (Everts), *Sitophilus oryzae* L., *Rhizopertha dominica* Fab. and *Tribolium castaneum* (Herbst), which cause heavy economic damage and destroy the quality and the quantity of the grain (Jafar *et al.*, 2012). Among them, *T. granarium* is one of widespread and key pests of many stored grain products, especially tropical areas. Comparatively larvae in comparison to adults are more damaging (Parashar, 2006; Burges, 2008; Mark *et al.*, 2010). Due to its attack, the value of wheat grains or flour reduced in the market and it not good for consumption (Perez *et al.*, 2003). Beside stored wheat, *T. granarium* also found in other grain stores, mart houses, food stores, stores of food packing materials, fodder production plants, seed processing plants, merchant stores and dried milk factories (Dwivedi and Shekhawat, 2004). Adults of Khapra beetle are brownish in color with a smooth oval-shaped body 2-3 mm long and 1-2 mm wide, female larger in size than males and males are lighter in wheat. Three transverse bands (markings) of pale color hairs are found on the wing covers. Newly emerged grubs are reddish-brown in color and can grow up to 7 mm long. The main characteristic of the grub is it posse's long hairs all over their body, particularly at the posterior. The immature grub can survive over 12 months in food scarcity conditions (Rao *et al.*, 2005).

Mainly chemicals are used to manage the stored pests, however, many of them are zardous to humans and other living organisms. Botanical insecticides are less toxic, cheap in price, easily available; degrade rapidly in the environment as well as in the body and no or less harmful to non-targeted species. In recent decades, many plant products in the shape of powders, essential oils and extracts have been isolated and tested against many stored insect pests to decrease losses of stored grains (Ofuya *et al.*, 2007). Neem plants contain several thousands of chemical constituents having insecticidal properties. Enormous active ingredients are found in various parts of the neem but mostly have been found concentrated in seed kernels (Mondal and Mondal, 2012). The

extracted essential oil from turmeric (*Curcuma longa* L.) leaves was found to be insecticidal with both contact and fumigant toxicity potentials. Mint (*Mentha piperita*) oils decreased the fecundity of female moths of *S. littoralis*. Moreover, mint oils have huge effect on different growth stages of the cutworms and react as a stomach and contact poisons on the larvae of cutworms (Tripathi, 2002).

Therefore, the aim of this study was to evaluate the efficacy of different plant extracts in the management of *T. granarium*. This approach was allowed discovering natural and safer agents for the development of bio-rational insecticides.

Objectives of the study

To determine the effect of different plant extracts against *T. granarium* under laboratory conditions.
To determine the weight loss of wheat due to the infestation of *T. granarium*

2. MATERIALS AND METHODS

Experimental Area

The experiment was carried-out Stored Grain Research Laboratory, Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University Tando Jam.

Insect Collection and Rearing

The culture of *T. granarium* was obtained from Grain Storage Research Laboratory, Karachi University. *Trogoderma granarium* population was further reared on the pure wheat flour under controlled temperature (28±5°C) and 75±5% R.H.

Plant Materials

Four plant species were selected as pest protectants i-e. Neem (*Azadirachta indica* A. Juss), Turmeric (*Curcuma longa* L.), Ajwain (*Carum copticum*) and Mint (*Mentha longifolia)*.

Extract Preparation

The plant materials were air-dried under shade in the laboratory. The dried plant materials were ground using electric blender (GEEPAS China GCG289) and sieve by muslin cloth to get the fine powder. The obtained powders of the plant materials were stored in clean plastic jars for their use in the study.

Experimental Outline

Powder of each treatment was applied at the rate of 2% into 20 grams of wheat grain (TD-1) in individual Petri dishes to observe the effect of different plant materials on the mortality of beetles. The powder was shacked thoroughly in seed for three minutes to create a homogenous mixture. In an individual Petri dish, 10 freshly emerged *T. granarium* were transferred.

The population fluctuation of *T. granarium* in wheat treated with various plant materials, 2% into 200 grams of wheat in plastic jars. In each jar, 20 freshly emerged beetles were transferred. The experiment was organized in a Completely Randomized Design (CRD) and all the treatments were replicated thrice.

Determination of Pest Damage Parameters

The toxicity of the plant's extracts was recorded after 24 hours, 48 hours and 7 days, the numbers of live and dead *T. granarium* were counted. Moreover, for population fluctuation of *T. granarium*, observations on number of live beetles were taken at monthly intervals for three consecutive months. Weight loss after three months in the individual treatments was also recorded. The data recorded for various observations were then analyzed using SAS 9.3 statistical software and the means with significant differences were compared using the Least Significant Difference (LSD) at 0.05 significant level.

3. RESULTS

The purpose of this study is to study the effects of extracts from different plants on *T. granarium* in wheat under laboratory conditions. All the botanical materials used exhibited the potential to cause mortality of *T. granarium* and their effectiveness against *T. granarium* increased with the passage of time. The detailed results are discussed below:

Effect of botanical extracts on the mortality of *T. granarium* at different intervals

The mortality rate of *T. granarium* in wheat due to the application of various plant extracts i.e., neem, turmeric, ajwain and mint after 24 hours, 48 hours and 1 week of their application are given in Table 1. It has been observed that initially not all the plant extracts

caused any substantial effect to induce mortality of the target *T. granarium*. Thus, after 24 hours of application, no significant difference (F = 1.45, P < 0.2867) was recorded among various plant materials to elicit mortality of *T. granarium*. Accordingly, in comparison to no mortality observed in control wheat treatment, mint treatment caused highest mortality (1.00±0.58), whereas, 0.67±0.67 mortality was observed in turmeric treated wheat. Afterward, an increase in the efficacy of treatments was recorded as mortality percentage showed a rising trend in various treatments, especially mint (2.67±0.33), followed by turmeric (1.33±0.33), ajwain (1.33±0.33) and neem (1.00±0.58). Accordingly, after 48 hours of application of various treatments, a significant difference (F =3.71, P <0.0420) was observed in mortality of *T. granarium*. After one week of application, mortality of *T. granarium* increased in mint treatment (9.33±0.33) that caused maximum death of the treated insects. The mortality of *T. granarium* observed in neem, turmeric and ajwain after one week was 8.33±0.67, 6.67±0.88 and 6.67±0.88, respectively. Therefore, a significant difference (F =7.11, P <0.0056) was recorded in the mortality of beetles due to the application of various plant extracts after one week of application.

Overall, at the end of the week, the highest mortality percentage of *T. granarium* was recorded in mint that caused 93.30% mortality. The mortality percentage recorded in neem, turmeric, ajwain and control at the end of week was 83.30%, 66.70%, 66.70% and 13.30%, respectively.

Table 1 Effect of different botanical extracts on the mortality of *T. granarium* at different intervals under laboratory conditions.

Treatment	Pre-treatment Population	24 hours	48 hours	1 Week	Mortality %
Neem	10	-	1.00±0.58b	8.33±0.67a	83.30%
Turmeric	10	0.67±0.67a	1.33±0.33b	6.67±0.88b	66.70%
Ajwain	10	1.33±0.67a	1.33±0.33b	6.67±0.88b	66.70%
Mint	10	1.00±0.58a	2.67±0.33a	9.33±0.33a	93.30%
Control	10	-	0.67±0.33b	1.33±0.67c	13.30%

*Means followed by the same letters in the column are not significantly different (LSD, P <0.05)

Effect of botanical extracts on the population fluctuation of *T. granarium*

Results for the population fluctuation of *T. granarium* in wheat treated with different plant extracts are shown in Table 2. A highly significant difference was recorded in the population of *T. granarium* in different plant extracts treated wheat after the first month (F =27.6, P <0.0000), second month (F =8.94, P <0.0024) and third month (F =35.3, P < 0.0000) of observations. After one month, the highest mean population was recorded in control (23.33±1.45 beetles), followed by ajwain (12.00±1.15 beetles) and turmeric (10.33±1.20 beetles). After two months, the highest (28.00±3.21 beetles) and lowest (11.67±1.76 beetles) *T. granarium* population was recorded in control and mint treatments. Accordingly, at the end of month three, the maximum population of beetles was recorded in control (41.67±2.60 beetles), whereas, the beetle population observed in ajwain, turmeric and neem treatments were 30.00±2.08 beetles, 29.33±1.45 beetles and 17.33±1.20 beetles, respectively.

Table 2 Effect of different plant extracts on the population fluctuation of *T. granarium* in wheat under laboratory conditions.

Treatment	Pre-treatment population	1st month	2nd month	3rd month
Neem	20	7.67±1.76d	13.33±0.88c	17.33±1.20c
Turmeric	20	10.33±1.20c	22.00±2.08b	29.33±1.45b
Ajwain	20	12.00±1.15b	22.33±2.73b	30.00±2.08b
Mint	20	5.33±0.88d	11.67±1.76c	16.33±0.88c
Control	20	23.33±1.45a	28.00±3.21a	41.67±2.60a

*Means followed by the same letters in the column are not significantly different (LSD, P <0.05)

Weight loss of wheat mixed with different plant extracts by *T. granarium*

The weight loss in wheat due to the feeding of *T. granarium* under the effect of plant extracts mixed with wheat is given in Table 3. According to the results, the highest grain weight loss of wheat due to the infestation of *T. granarium* was recorded in control (54.67 grams or 27.33%), followed by ajwain treatment (31.00 grams or 15.67%). The lowest overall weight loss was observed in mint treatment (16.67 grams or 8.33%), followed by neem (18.33 grams or 9.17%) and turmeric (28.00 grams or 14.00%) treatments. Accordingly, the various treatments showed a highly significant (F = 68.0, P < 0.0000) difference in overall weight loss due to the

infestation of beetles and influenced by the addition of plant materials. Results also indicated that grain weight loss in various treatments differs significantly (F =61.8, P <0.0000) due to feeding of *T. granarium* as significantly the highest grain weight loss at the end of experiment was observed in control (65.67 grams or 32.83%), followed by ajwain (39.33 grams or 19.67%) and turmeric (36.33 grams 18.17%) treatments. Moreover, the lowest overall weight loss was recorded in mint (22.00 grams or 11.00%) and neem (24.67 grams or 12.33%) treatments.

Table 3 Weight loss of wheat mixed with different plant extracts by *T. granarium* under laboratory conditions

Treatment	Initial weight (g)	Final weight (g)	Grain weight(g)	Overall weight loss (grams / %)	Grain weight loss (grams / %)
Neem	200 (g)	181.67±1.45A	175.33±1.20b	18.33 (9.17%)	24.67 (12.33%)
Turmeric	200 (g)	172.00±2.00B	163.67±2.19c	28.00 (14.00%)	36.33 (18.17%)
Ajwain	200 (g)	168.67±1.86C	160.67±1.45c	31.00 (15.67%)	39.33 (19.67%)
Mint	200 (g)	183.33±0.88a	178.00±1.15a	16.67 (8.33%)	22.00 (11.00%)
Control	200 (g)	145.33±2.91D	134.33±3.53d	54.67 (27.33%)	65.67 (32.83%)

*Means followed by the same letters in the column are not significantly different (LSD, P <0.05)

4. DISCUSSION

Laboratory studies were conducted in the Department of Entomology to evaluate the effect of various botanical pesticides against *T. granarium* in wheat regarding its damage and mortality. The botanical pesticides in the experiment were neem, turmeric, ajwain and mint in the powder form. The data was recorded regarding the mortality, population fluctuation and weight loss of wheat caused by *T. granarium,* after the application of the botanical mentioned above. Mortality data showed that mint caused the maximums mortality of the targeted *T. granarium*, followed by neem, ajwain and turmeric, whereas the lowest mortality was recorded in control. Moreover, population fluctuation of *T. granarium* in wheat mixed with plant extracts indicated that the maximum population growth of pest was recorded in control, followed by ajwain, turmeric and neem treatments. The mint powder showed the highest effect on growth rate of *T. granarium*. In continuity with mortality and population data, the lowest weight loss of wheat was recorded in mint treated wheat, whereas, the highest overall and grains weight loss was recorded in control, followed by ajwain, turmeric and neem. Previous studies have identified the important role of different plant extracts in the management of *T. granarium*, hence, our stored wheat face minimum losses from it. There are several insect pests of stored grains caused severe infestations to stored food and food products and cause heavy economic losses to stored commodities. Khapra beetle has three years starvation capabilities so it becomes one of the most disparaging insect pests that have great economic importance. This pest also has best growth rate at low relative humidity as compared to other stored grain pests. By their heavy infestation the quality and quantity of stored products were reduced. The resistance was also reported in khapra beetle against phosphine, malathion and pyrethroids insecticides, has further increased its economic importance. Satti and Elamin (2012) confirmed the potential of neem oil extract and reported that the neem oil caused 92.5% mortality of third instars larvae after third week of their exposure. Whereas, 85.4% repellency was also reported against *T. granarium* larvae. Javed *et al*., (2016) tested different plant extracts to control the infestation of khapra beetle and the reported efficacy of extracts were *E. sativa* caused highest (98.47%) beetles mortality followed by *W. somnifera* (92.33%) and *P. nigrum* (78.60%). Similarly, the extract of *D. stramonium* exhibited highest effect on mortality, population build-up larval emergence and adult emergence. Lowest grain weight loss was also recorded in *D. stramonium* extract (Islam *et al*., 2017).

Hanif *et al*. (2015) reported significant impact of extracts of *A. indica* and *D. stramonium* against *T. granarium* larvae. The maximum mortality was observed in *D. stramonium* oil. Moreover, mixed use of phosphine and essential oils significantly increased mortality percentage of the targeted khapra beetles.

Therefore, results of the all above-mentioned studies confirmed that many plant extracts have potential to be used as potential insecticides against stored grain pests and especially against *T. granarium*. The plant extracts evaluated in the studies showed various properties ranging from repellency to the mortality of insect pests. In this study, mint, turmeric and neem cause the promising mortality with maximum mortality recorded in mint. Accordingly, all these plant extracts also retard the growth of the *T. granarium,* as no rapid reproduction and growth was recorded in all the treatments of the plants used in the study. In comparison, highest growth and development of the pest was recorded in the control.

5. SUMMARY, CONCLUSION AND SUGGESTIONS

Summary

Wheat is the staple food for the majority of population in Pakistan, however, in storehouse's grains of wheat is infected with many insect pests. Major insect pests of stored wheat include red flour beetle (*Tribolium castaneum*), Khapra beetle (*Trogoderma granarium*), maize weevil (*Sitophilus zeamais*), lesser grain borer (*Rhyzopertha dominica* F.), larger grain borer (*Prostephanus truncates*), granary weevils (*Sitophilus granarius*), angoumois grain moth (*Sitotroga cerelella*), rice weevil (*Sitophilus oryzae*) and Indian meal moth (*Plodia interpunctella*). Among the pests, *T. granarium* is one of the serious pests of wheat worldwide. Mostly synthetic fumigants are used to control the populations of stored grain pests; however, all such fumigants are also harmful to humans due to direct consumption of grains by the humans. This is why research in recent years has focused on the safe use of plants and microorganism in combating these pests with treatment. Therefore, this study was undertaken to evaluate the insecticidal effect of different plant materials against *T. granarium* under laboratory conditions. The plants used in the study were neem, turmeric, ajwain and mint. Results of the study indicated promising effect of all the materials to cause mortality of *T. granarium* in wheat after one week with 93.30% mortality recorded in mint, followed by neem (83.30%), turmeric (66.70%), and ajwain (66.70%). All the botanical materials used exhibited the potential to cause mortality of *T. granarium* and their effectiveness against *T. granarium* increased with the passage of time. Significant results for the population fluctuation of *T. granarium* in wheat treated with various plant extracts were observed. At the end of third month, the maximum population of *T. granarium* was recorded in control (41.67±2.60 beetles), whereas, the lowest (16.33±0.88 beetles) population observed in mint treatment. The population of beetle in remaining treatments i.e., ajwain, turmeric and neem treatments was recorded as 30.00±2.08 beetles, 29.33±1.45 beetles and 17.33±1.20 beetles, respectively. In view of the mortality and population development among various treatments, overall the highest and lowest weight losses of wheat were recorded in control (27.33%) and mint (8.33%) treatments, respectively. Similarly, *T. granarium* caused the maximum weight loss of grains in control (32.83%), whereas, the minimum grain weight loss was recorded in mint treatment (11.00%).

Conclusions

Following conclusions have been drawn from the study undertaken.

All the plant materials showed toxic properties against the *T. granarium*.

Maximum (93.30%) mortality was recorded in the mint treatment.

Control exhibited the maximum population growth of *T. granarium*, whereas, the lowest population growth was recorded in mint.

The maximum and minimum weight losses were recorded in control and mint treatments, respectively.

Suggestions

Based on findings of the study, following recommendation is suggested:

Mint powder and neem powder should be used in stored grains especially wheat against *T. granarium*.

Further studies should be conducted on the use of various concentrations of the botanicals and time exposures against *T. granarium* to determine the optimum dose and time to cause maximum mortality of *T. granarium*.

Appendices

Appendix-I Analysis of variance for effect of various plant extracts on mortality of *Trogoderma granarium* after 24 hours

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	4.2667	1.06667	1.45	0.2867
Error	10	7.3333	0.73333		
Corrected Total	14	11.6000			

Appendix-II Analysis of variance for effect of various plant extracts on mortality of *Trogoderma granarium* after 48 hours

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	6.9333	1.73333	3.71	0.0420
Error	10	4.6667	0.46667		

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Corrected Total	14	11.6000			

Appendix-III Analysis of variance for effect of various plant extracts on mortality of *Trogoderma granarium* after 1 week

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	43.6000	10.9000	7.11	0.0056
Error	10	15.3333	1.5333		
Corrected Total	14	58.9333			

Appendix-IV Analysis of variance for effect of various plant extracts on population of *Trogoderma granarium* after one month

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	582.267	145.567	27.6	0.0000
Error	10	52.667	5.267		
Corrected Total	14	634.933			

Analysis-V of variance for effect of various plant extracts on population of *Trogoderma granarium* after second month

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	557.733	139.433	8.94	0.0024
Error	10	156.000	15.600		
Corrected Total	14	713.733			

Appendix-VI Analysis of variance for effect of various plant extracts on population of *Trogoderma granarium* after third month

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	1310.27	327.567	35.3	0.0000
Error	10	92.67	9.267		
Corrected Total	14	1402.93			

Appendix-VII Analysis of variance for effect of various plant extracts on weight loss of wheat due to *Trogoderma granarium*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	4	2783.73	695.933	61.8	0.0000
Error	10	112.67	11.267		
Corrected Total	14	2896.40			

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